Nature Conservation 63: 153–171 (2026)
DOI: 10.3897/natureconservation.63.186090

Research Article

# Semi-natural meadow conservation under pressure: Farmers' decision-making in intensifying lowland agricultural systems

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## Abstract

Despite their high nature conservation value and protection through the EU Habitats Directive (92/43/EEC), extensively managed semi-natural grasslands are often disappearing rapidly from European landscapes. Given the limited success of agricultural policy interventions in curbing grassland loss, a better understanding of farmers' decision-making regarding grassland management is needed. This study explored the determinants of extensively managed meadow conservation in two lowland regions in Slovenia using mixed methods – qualitative analysis of interviews with farmers and quantitative modelling using machine learning. The results of our quantitative model indicate that the most influential predictors of extensive meadow preservation are increased plot size, greater distance from roads, higher share of rented land and share of meadows on the farm, as well as close proximity to water. These meadows thus often seem to be productively marginalised due to flooding, remoteness or low drainage. While farmers in our interviews valued extensive meadows for their aesthetic beauty, it is the productive value and social norms that typically drive their decisions favouring grassland intensification. Although some farmers appreciated the possibility of being compensated for extensive grassland management under agri-environmental measures, these measures do not act as a sufficient motivator for extensive meadow conservation.

**Key words:** High nature value farming, mixed methods, semi-natural grassland, Slovenia

OPEN ACCESS

Academic editor:
Robert Philipp Wagensommer
**Received:** 22 January 2026
**Accepted:** 6 March 2026
**Published:** 31 March 2026

ZooBank: https://zoobank.org/D888DE53-8A81-40E2-B6D2-42BFFF8C2138

**Citation:** Alif Ž, Novak A, Šumrada T (2026) Semi-natural meadow conservation under pressure: Farmers' decision-making in intensifying lowland agricultural systems. Nature Conservation 63: 153–171. https://doi.org/10.3897/natureconservation.63.186090

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## Introduction

Millennia of extensive traditional agricultural practices in Europe have led to the development of semi-natural grasslands (Bignal and McCracken 2000). These ecosystems are among the most biodiverse both in Central Europe and globally, therefore holding an exceptionally high conservation value (Wilson et al. 2012; Sutcliffe et al. 2015). However, these ecosystems and their services have experienced dramatic declines across Europe in the last decades and are increasingly threatened (Hooftman and Bullock 2012; Ridding et al. 2020, Pisani et al. 2021; Drius et al. 2025), despite their legal protection under the EU Habitats Directive and the Natura 2000 network (Anon 2013). The most recent EU-level assessment shows that almost 70% of semi-natural grasslands, which depend on agricultural management, are in a bad conservation state, which means that the habitats are in serious danger of disap-

pearing at least regionally. Over 60% of semi-natural grasslands continue to deteriorate (European Environment Agency 2020). Furthermore, as semi-natural grasslands provide essential habitats for many species that use them for reproduction, food and shelter, this degradation has also contributed to population declines in birds, pollinators and other taxa (Potts 2016; European Environment Agency 2020; PECBMS 2022; Van Swaay et al. 2022; Douglas et al. 2023). Hence, it is crucial to conserve and restore semi-natural grasslands in Central Europe, such as habitat types (HT) 6210, 6410 and 6510, both within and outside protected areas, which is also recognised by the new Nature Restoration regulation (Anon 2024).

Biodiversity loss in semi-natural grasslands is driven by two contrasting processes. On the one hand, the low economic profitability of semi-natural grasslands in marginal areas leads to land abandonment, resulting in shrub encroachment and overgrowth (McGinlay et al. 2017; Schils et al. 2020; Shipley et al. 2024). On the other hand, agricultural intensification leads to a direct loss of grasslands through conversion to arable land, or to changes in grassland composition and structure due to altered nutrient and water regimes, increased mowing frequency and higher livestock density (Duprè et al. 2010; Shipley et al. 2024). These processes not only alter the plant species composition and often decrease the species richness, but also lead to declines in animal diversity (Hempel et al. 2025). Consequently, the conservation of semi-natural grasslands depends on maintaining a management regime with a balanced land-use intensity: agricultural use must be sufficiently intensive to prevent overgrowth, yet not intense enough for the fast-growing species to dominate (Shipley et al. 2024). In addition, each habitat type requires specific management practices regarding frequency and timing of mowing and grazing intensity that also need to be locally adapted (e.g. Olmeda et al. 2019).

As the conservation of semi-natural grasslands relies on low-intensity agricultural management, agricultural policy instruments are key tools for steering farmers' grassland management decisions (Röder et al. 2024). As part of the Common Agricultural Policy (CAP), EU Member States have established agri-environmental-climate measures (AECM) that compensate farmers for adopting extensive grassland management practices (Waldén and Lindborg 2018; Pe'er et al. 2022; Shipley et al. 2024). In many countries, management restrictions have also been applied on converting permanent grassland into arable land, usually within the Natura 2000 network (Pe'er et al. 2022). However, despite these measures, there is little evidence of improvement in the state of meadows. This lack of progress is attributed both to the limited ambition and inadequate spatial targeting of existing measures, and to low enrolment by farmers in the more demanding AECMs (Dicks et al. 2014; Jones et al. 2016; Alliance Environment 2019; Kaligarič et al. 2019; Pe'er et al. 2019).

To design more effective policy interventions for the conservation and restoration of semi-natural grasslands, a better understanding of the social and economic processes that drive changes in their management is needed (de Snoo et al. 2013), while ensuring verification of the conservation state of the grasslands through vegetation monitoring (Ellwanger et al. 2018). Numerous studies have examined farmers' decision-making regarding environmental measures, particularly AECM. Overall, farmers' management decisions are influenced by various structural, economic, social, demographic, and behavioural factors, but

are also moderated by the local context and opportunity costs arising from it (Klebl et al. 2023; Schaub et al. 2023; Canessa et al. 2024; Thompson et al. 2024). It remains unclear which of these factors play the most important role in farmers' decisions regarding the management of permanent grassland.

The aim of this paper is to comprehensively examine the determinants of farmers' decision-making regarding the conservation of selected habitat types of extensively managed semi-natural grasslands in two case study areas susceptible to intensification. We use a mixed-methods approach, combining quantitative and qualitative analyses, and examine a broad set of structural, behavioural, physical-geographic and economic variables. As a case study, we focus on two lowland regions in Slovenia where intensification has already occurred or is currently underway, allowing us to explore how differing intensification trajectories shape farmers' perspectives and management choices.

## Methods

### Study area

The study was conducted in two lowland regions of Slovenia: Ljubljansko barje and Dravsko-ptujsko polje (Fig. 1). These areas represent contrasting levels of agricultural intensification and vegetation cover, which serve as a baseline for comparison of the physical-geographic factors and farmers' decision-making regarding removal and restoration of extensive meadows and woody landscape features.

Ljubljansko barje (135.6 $km^2$, 1,060 farms) experiences frequent flooding and high soil moisture, making permanent meadows (covering 39% of the land area) the primary land use, while maize and cereals are grown on the remaining arable land to supply cattle feed for the region's beef farming industry. The area is designated as a protected nature park and a Natura 2000 site, with biodiversity conservation focused on extensive management of wet meadows (Vreš et al. 2016). The main three grassland habitat types in the area, which were also the focus of our study, are 6410 (Molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae* W. Koch, 1926), 6430 (Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels, in our study area belonging to the *Filipendulion ulmariae* Segal ex Westhoff & Den Held, 1969 alliance)), and 6510 (Lowland hay meadows (*Alopecurus pratensis* L., *Sanguisorba officinalis* L.), which are composed of communities belonging to the *Arrhenatherion elatioris* W. Koch, 1926 alliance), while 7230 (Alkaline fens, belonging to *Caricion davallianae* Klika, 1934 alliance) remain in small fragments only (Šilc et al. 2023). In recent years, agricultural practices have intensified, with increased drainage, earlier mowing schedules, meadow conversion to arable land, and hedgerow removal (Miličić et al. 2011). This led to rapid declines in species dependent on wet meadows, such as false ringlet (*Coenonympha oedippus* Fabricius, 1787) and corncrake (*Crex crex* Linnaeus, 1758) (Jančar 2018; Denac 2021; Čelik 2022).

Dravsko-ptujsko polje (414 $km^2$, 2,450 farms), located in northwestern Slovenia, is a predominantly arable landscape (53% of the area). This region ranks among the most important Slovenian regions for agricultural production (Žiberna and Ivajnšič 2022), with predominantly mixed arable and livestock farming. In this study area, wet meadows have already almost completely disappeared

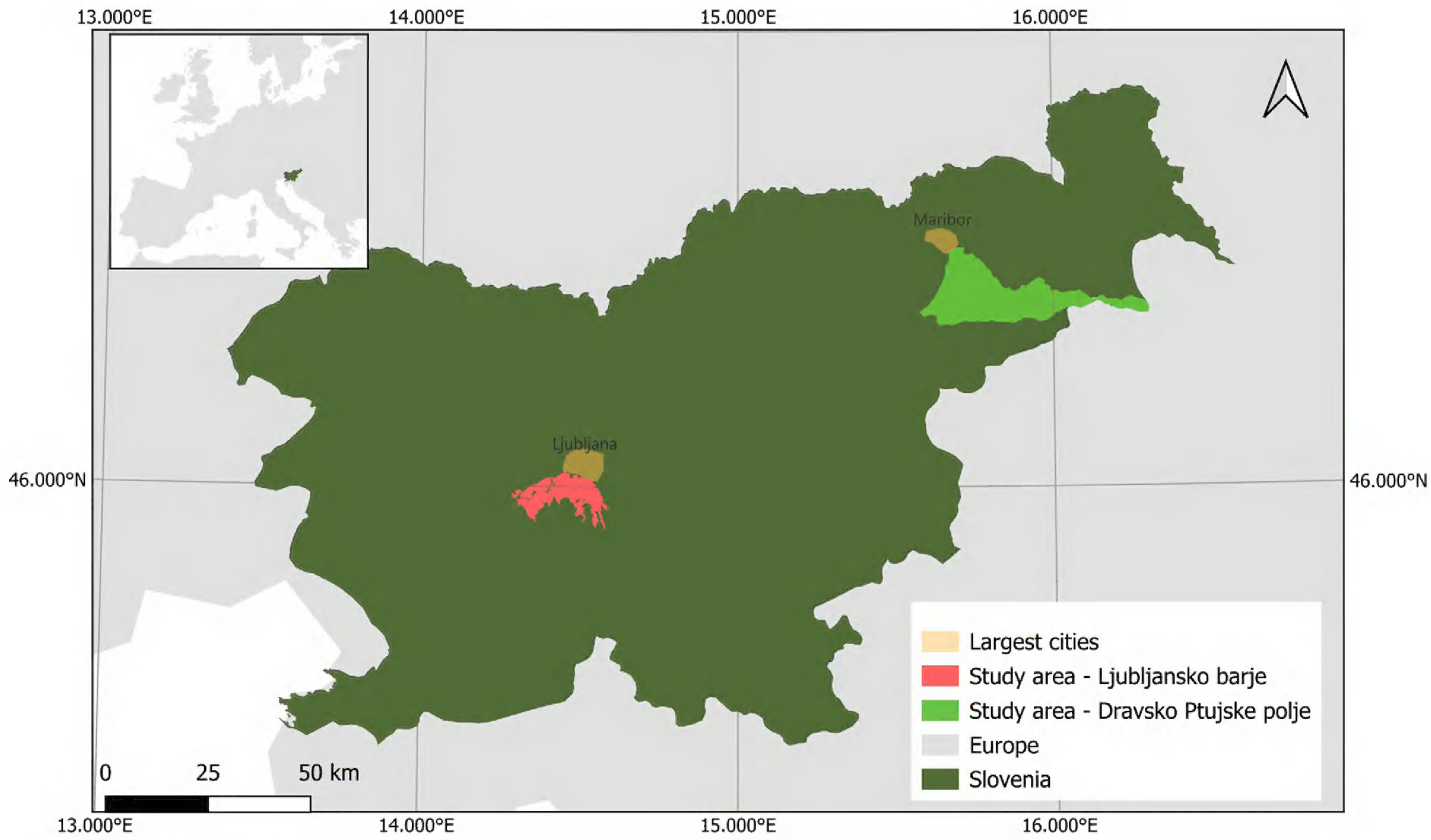


**Figure 1.** Study area map.

(Horvat et al. 2023). The most common habitat types of the remaining extensive grasslands are 6510 (Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)) and 6210 (Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometea* Br.-Bl. & Tx. ex Soó, 1947)), among which the latter is mostly found on skeletal soils along the Drava river.

Our study focuses on extensively managed meadows, where suitable management regime was defined by the conservation experts as meadows without grazing and fertilisation and mowing dates after July 10$^{th}$ (Šilc et al. 2023). These recommendations were developed specifically for the targeted habitat types in Ljubljansko barje (6410, 6430 and 6510) with mowing dates and avoidance of grazing also allowing for successful breeding of the ground-nesting grassland bird species (Denac 2007; Vukelič 2009). A similar recommendation has also been applied to the other case study in the Dravsko-ptujsko polje. Although light grazing and fertilisation are possible for both targeted habitat types (6210 and 6510) in Dravsko-ptujsko polje due to skeletal soils, avoidance of fertilisation and grazing was still recommended due to specific local characteristics of the area and targeted management for animal species, such as ground-nesting grassland birds. The recommended mowing date for this area was in early July based on the typical timing of grassland plant seed ripening. In contrast to Western Europe, cattle in Slovenia, including in these two regions, were historically kept mostly in stables, and grasslands were typically mown (Košar 2008; Hribar 2016). Grazing still remains rare, present on less than 5% of the area of Ljubljansko barje (Čop et al. 2004), while in Dravsko-Ptujsko Polje cattle breeding is rare (e.g. only 12% of farms in our sample solely breed cattle) and livestock feed for other animals is mainly produced on arable land.

In the 2014–2022 CAP programming period, when the study was conducted, there were two AECM in Ljubljansko barje aimed at preserving wet meadow habitats (HT 6410 and HT 7230) that meet the conditions of extensive meadows set in this study. Farmers can receive a payment of 329.79€/ha/annum for the "Hay meadows" scheme and 349.99 to 386.59 €/ha/annum (plus a possible extra bonus for the presence of corncrake *Crex crex* in vicinity) for the "Birds of wet grasslands" scheme (MKGP 2024). Unlike Ljubljansko barje, Dravsko-ptujsko polje has been highly intensified, with only 6% of its area covered by permanent meadows (Ivajnšič et al. 2024). Dravsko-ptujsko polje is therefore an area where restoration of extensive meadows may be necessary.

## Survey description and data collection

Data were collected between February and May 2022 using face-to-face surveys with any farmer who had land in our study areas. Before the interview, we briefed the farmers regarding the purpose of the study, data management and their rights, and obtained farmers' consent to participate in the study, obtain their Integrated administration and control system (IACS) number and record the interview (Suppl. material 1). We interviewed 244 farmers in Ljubljansko barje and 262 farmers in Dravsko-Ptujsko Polje (506 in total), of which 188 and 202 interviews were recorded in each area, respectively (390 in total). The IACS number enabled us to later connect survey data to IACS data on farming activities, farmland location and received subsidies. Furthermore, we used the IACS number to obtain a map of all agricultural land on an individual farm and to estimate the surface area of all extensive meadows. We collected participants' farm-related- and socio-economic data as well as attitudinal data related to extensive meadows. The full survey is available in Suppl. material 1.

## Farm characteristics and share of extensive meadows

In total, we obtained 506 responses, which represents 14% of all farms in the two study regions. The respondents were representative of all farm holdings in the two study areas in terms of age, farm size, organic farming enrolment, and livestock units per ha. However, as shown in Table 1, a somewhat higher proportion of our respondents were male, had livestock, and were enrolled in AECM than in the entire population. Most farms had cattle, received little income from farming, did not diversify their farming activities, and planned to keep the same farm size. Respondents mostly had secondary education.

## Quantitative analysis

We digitalised extensive meadows mapped in the survey using QGIS software (QGIS Development Team n.d.). We transformed the mapped elements into a presence/absence map by treating all meadows that were identified in the survey as extensively managed as presence points. The habitat type was therefore determined through a combination of previous mapping of habitat types in the study areas and discussion with the farmer on how they manage the grassland in terms of mowing dates and time, fertilisation, grazing, and biomass use. All meadows on surveyed farms listed in the IACS database that were

**Table 1.** Characteristics of surveyed farms. P-values were produced with t-tests for continuous variables and chi-squared tests for categorical variables.

| Characteristcs | Population | Surveyed farms | p-value |
|---|---|---|---|
| Number of farms (n) | 3525 | 506 | |
| Age | 59,5 (SD = 14.56) | 58.11 (SD = 13.82) | p = 0.052 |
| Gender (n) | 951 F (30.1%) | 109 F (26.4%) | p = 0.012 |
| Farm size (ha) | 15.69 (SD = 72.02) | 19.99 (SD = 58.93) | p = 0.14 |
| Enrolled in AECM (n) | 708 (20%) | 193 (39%) | p < 0.001 |
| Organic farming (n) | 137 (3,9%) | 27 (5.4%) | p = 0.075 |
| Livestock farms | 1456 (70%) | 392 (79%) | p < 0.001 |
| Livestock units/ha | 15.40 (SD = 31.9) | 15.92 (SD = 30.6) | p = 0.800 |
| Meadow share on farm (%) | / | 38.3 (SD = 34.6) | / |
| Share of rented land (%) | / | 19.98 (SD = 24.1) | / |
| Future farm development | | | |
| Same size | / | 289 (57.1) | / |
| Expand | | 122 (24.1%) | |
| Reduce in size or stop farming | | 83 (16.4%) | |
| Production orientation | | | |
| Cattle | / | 153 (30.2%) | / |
| mixed | | 114 (22.5%) | |
| mixed arable production | | 162 (32.0%) | |
| mixed livestock | | 77 (15.2%) | |
| Income from farming | | | |
| <25% | / | 252 (49.8%) | / |
| 25–50% | | 114 (22.5%) | |
| 50–75% | | 47 (9.2%) | |
| <75% | | 83 (16.4%) | |
| Education | | | |
| Primary school or less | / | 77 (15.2%) | / |
| Secondary school | | 330 (65.2%) | |
| Higher education | | 99 (19.6%) | |
| Production attitude | / | 3.06 (SD = 1.36) | / |
| Conservation attitude | / | 3.81 (SD = 1.15) | / |
| Cultural value | / | 4.01 (SD = 1.07) | / |
| Farm diversification | / | 45 (8.9%) | / |

not identified as extensively managed, were treated as absence points. To predict extensive meadow presence/absence, physical-geographical location-level variables, socio-demographic variables, farm characteristics and attitudinal variables were used (see Suppl. material 2 for a full description of predictors). As there were only seven extensive meadows out of 321 meadows in total on Dravsko-ptujsko polje, the number of presence points in that region was too low to reliably model the data, hence this part of the analysis was only performed on Ljubljansko barje. Fig. 2 shows the two study areas with all the parcels belonging to the surveyed farms and extensive meadow presence and absence points that were used as data for the analysis.

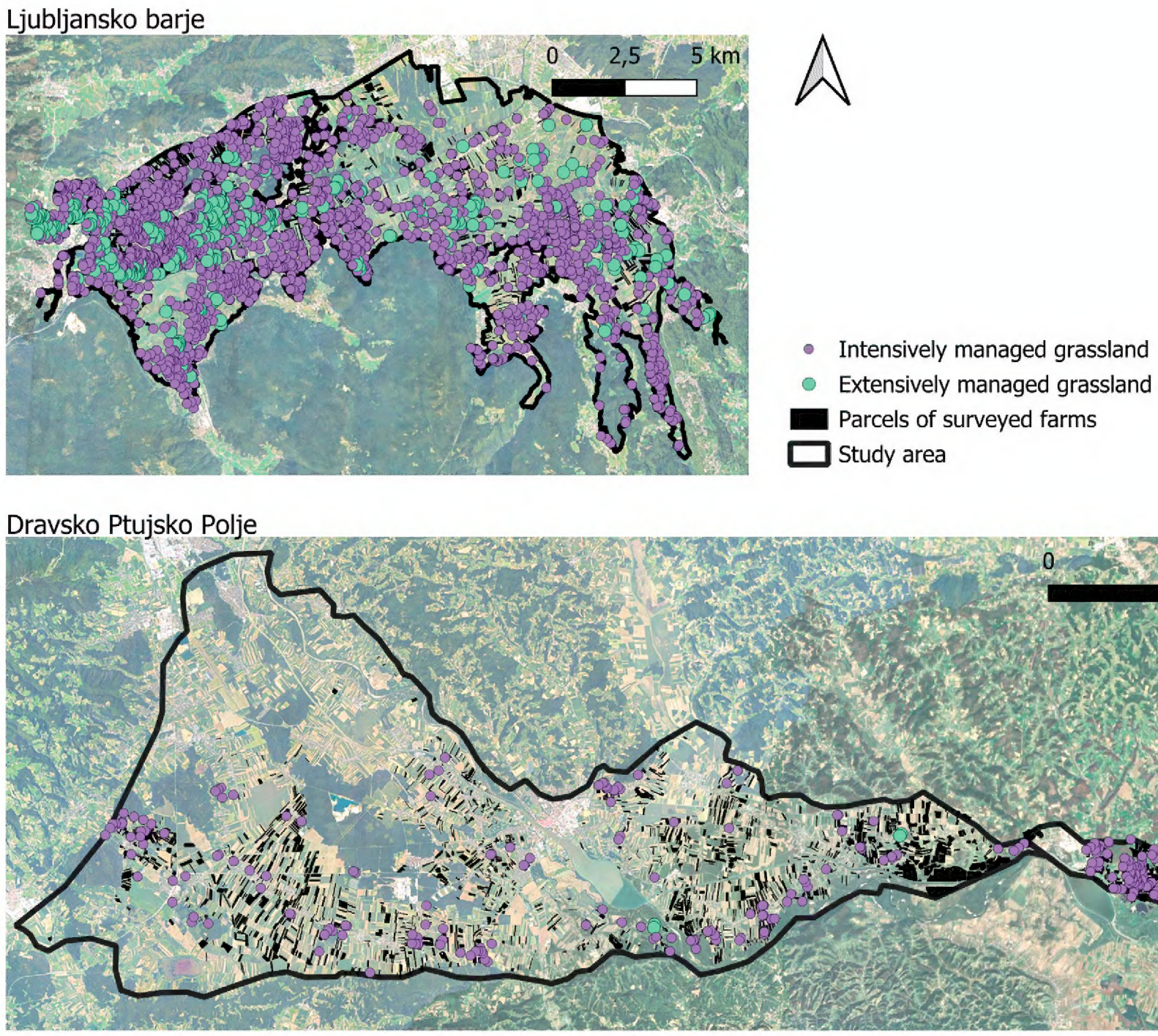


**Figure 2.** All surveyed land, extensively managed grasslands (presence points) and intensively managed grasslands (absence points) in Ljubljansko barje and Dravsko-Ptujsko polje study areas.

To analyse the data, we used boosted regression trees (BRT) modelling with a small learning rate of 0.01 and tree complexity of 5, while bag fraction was set to 0.5 (Elith et al. 2008). Cross-validation was used to assess the performance of all models with 10 randomly chosen subsets. This enabled the calculation of two model performance metrics: predictive deviance, expressed as a percentage of the null deviance, and discrimination ability, measured as the area under the receiver operating characteristic curve (AUC) (Elith et al. 2008).

While there are no p-values in BRT, the relative influence of all variables is scaled so that it sums up to 100%. The relationship between each predictor and response variable while controlling for the average effects of other variables in the model are visualised with partial dependence plots (Elith et al. 2008). To counter spatial autocorrelation, we added a residual autocorrelation term to the BRT model (Crase et al. 2012). BRT models were fit using packages dismo (Hijmans et al. 2023) and gbm (Greg and Developers 2024) in R version 4.3.3 (R Core Team 2024).

## Qualitative analysis

Out of 390 recorded interviews, 90 were randomly selected for more in-depth analysis with transcription and coding in ATLAS.ti software. Coding was conducted by two researchers to ensure consistency and interpretive reliability.

The coding framework was initially guided by the structure of the survey questionnaire and was subsequently expanded to incorporate themes that emerged from the data, following the principles of thematic analysis (Braun and Clarke 2006). The qualitative data analysis is complemented by survey data of the whole sample, which was analysed using descriptive statistics.

## Results with discussion

### Boosted regression trees

Currently, 4.32% of farmland of all respondents is under extensively managed semi-natural meadows, but there are considerable differences in these shares among the two study areas. Extensive meadows occur on 75 farms (32.5%) and cover 5.9% of surveyed farms on Ljubljansko barje, of which 43 farms are enrolled in AECM for extensive meadow conservation. On the other hand, only 7 farms in Dravsko-Ptujsko polje have any extensive meadows, covering only 0.007 % of the surveyed farm area. Among a total of 2,484 detected meadows in Ljubljansko barje, 317 meadows (12.7%) were identified as extensively managed and thus treated as presence points, while the remaining meadows served as absence points (Suppl. material 3).

The final BRT model with 450 trees achieved good predictive ability (training data: 52.2% total deviance explained; AUC = 0.947; CV data: 40% total deviance explained; AUC = 0.903). The relative influence of each variable is shown in Table 2. While the residual autocovariate term (rac) was the most influential predictor, other important predictors include plot size, road distance, share of rented land, share of meadows on farm, distance from water and farmers' attitudes towards the productive value of extensive meadows.

Partial dependence plots (Fig. 3) show that an increase in the plot size leads to an increase in the likelihood of an extensive meadow in a logarithmic fashion. This effect may arise because Ljubljansko barje is drained with ditches, dividing land into smaller plots. With increasing plot size, drainage is likely worse and hence less suitable for intensive land use. Increasing distance to roads increases the likelihood of extensive meadows linearly, but with a very small marginal effect, suggesting that meadows in less accessible, possibly more marginal locations are more extensive. By contrast, the likelihood of extensive meadows decreases with increasing water distance up to 400 m, with no detected effect at longer distances. This effect likely arises from frequent flooding in Ljubljansko barje, which prevents early mowing and intensive management of meadows near waterways.

The share of rented land has little effect over most of the variable range, but drastically increases the likelihood when the rented share is between 90% and 100%. This could result from farmers who do not own any land being forced to rent meadows of lower productive value that can only be managed extensively. While meadow share on the farm has no effect on the likelihood up to a 50% share, there is a weak positive association at high meadow shares, indicating that when a farm has a lot of meadows, it can afford to manage some extensively, as enough fodder can be produced elsewhere. Finally, positive attitudes of farmers towards the productive value of extensive meadows consistently increase the likelihood of extensive meadow presence, pointing to the

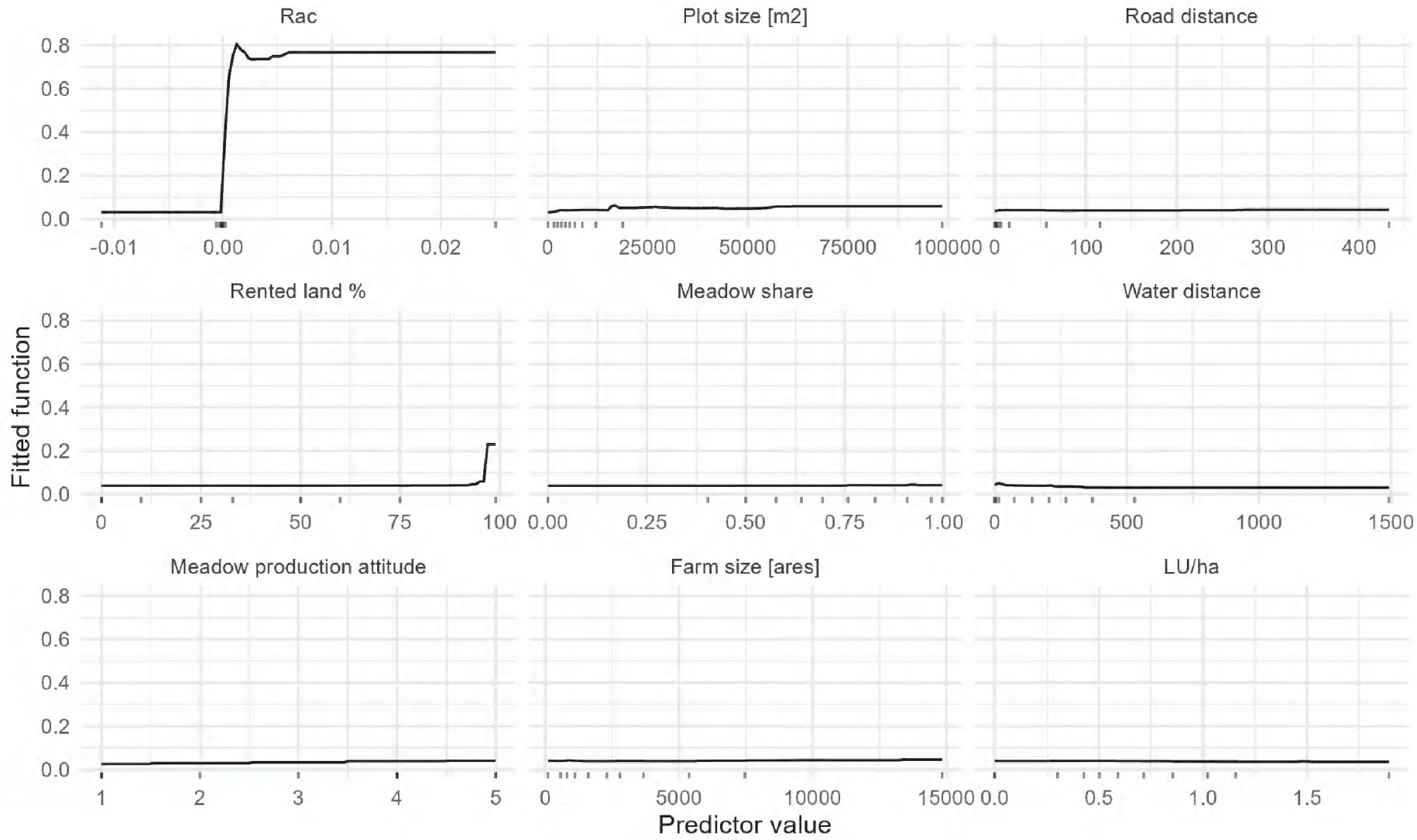


**Figure 3.** Partial dependence plots of the 9 most important predictors of the presence of extensive meadows in Ljubljansko barje (Slovenia). Dots at the bottom represent deciles of current data distribution. All distances are in meters while farm size and plot size are measured in ares.

**Table 2.** Relative influence (%) of each predictor.

| Variable | Relative importance |
|---|---|
| rac | 60.91 |
| Plot size | 6.49 |
| Road distance | 5.46 |
| Rented land | 4.50 |
| Meadow share | 3.59 |
| Water distance | 3.44 |
| Meadow production attitude | 3.24 |
| Farm size | 2.48 |
| LU/ha | 2.30 |
| Age | 2.14 |
| Production type | 1.52 |
| Meadow nature attitude | 1.10 |
| Cultural value | 1.01 |
| Soil type | 0.58 |
| Future prospects | 0.37 |
| Education | 0.24 |
| Farm-related income | 0.24 |
| Organic | 0.17 |
| Gender | 0.14 |
| Farm diversification | 0.08 |

relationship between individual farming management methods and the subsequent land use that we further explore in qualitative analysis.

It is interesting to note that the results of a similar study by Tsakiridis et al. (2022), which examined predictors of all semi-natural habitats (grasslands, but also woody, stony, and water landscape features) on Irish farms, were quite different from those in this study . While they found that soil type had a statistically significant and negative effect on semi-natural habitat, this predictor had a low predictive power in our study. Possibly, due to a limitation to one study area, sufficient variation in soil types was not captured in our study. Similarly, off-farm employment and different production orientations had statistically significant positive effects on the presence of semi-natural habitat, while both had lower-than-average predictive power in our study. In both Irish and our study, however, livestock units had a weak, but statistically significant/predictively important effect on the share of extensively managed landscape features. Possibly, the observed differences result from different methodological approaches and our narrower focus to extensively managed meadows. However, these differences also highlight the importance of studying the specific conditions of each region as they have the potential to influence farmer decision-making.

## The role and obstacles for maintenance of EM

Farmers across both study areas attributed a range of benefits and roles to extensively managed meadows. Many demonstrated a clear awareness of their ecological value and importance for biodiversity, which was also reflected in survey results, where preserving extensive meadows for nature conservation received a relatively high average score (mean = 3.8, SD = 1.31). They described such areas as refuges for wildlife, places where “hares and birds nest” (101) and where “wild animals can hide” (102). However, farmers tended to place the greatest emphasis on ecological roles that also provide tangible benefits to people and agricultural production. In particular, the respondents highlighted the importance of flowering meadows for pollinators, especially honeybees. Farmers noted that “if there are no flowers, the bees have nowhere to land” (103), often accompanied by a tone of worry that “when the bees die out, we [humans] will slowly disappear too” (104). Less frequently, the importance of allowing grasslands to flower and set seed was also articulated, particularly on smaller and more extensively managed farms. This reflected farmers’ understanding that seed dispersal is a key process for maintaining the vitality and productivity of meadows. These respondents often explained that premature mowing or intensive fertilisation can disrupt this process, warning that “after a few years it’s no longer a meadow” (105) and that “the grasses can disappear” (106).

In addition to ecological benefits, some farmers also attributed aesthetic and experiential value to extensive meadows. They contrasted the visual richness of flower-rich meadows with the uniform appearance of intensively managed fields, noting that “it’s nicer when there are some blossoms” (107). Others described the sensory experience of being in such meadows: “if a meadow has flowers and you lie down under a tree, the birds are singing, there are butterflies, and you just enjoy it” (108). At the same time, it was evident that strong social norms shape how grasslands were expected to look. Respondents repeatedly described a prevailing expectation that land should be regularly and visibly managed, equating “nice-

ly mown" meadows with "proper" farming. Allowing grass to grow taller or older was therefore often described as "abandoned" or "not cultivated". Several farmers expressed concerns about how neighbours would react if they delayed mowing, explaining that "people would look and say I'm not mowing at all… it would feel awkward" (109), or even that "the whole village would laugh at me" (110). Farmers renting land also noted that landowners often oppose delayed mowing.

These social norms regarding the visual appearance of meadows were closely linked to changing perceptions of their agricultural value, which farmers frequently contrasted with the former role of extensive meadows in agricultural production. Historically, extensively managed meadows played a practical role within mixed farming systems. Respondents from both regions recalled that such meadows were far more common in the past than they are today. Many described how, during their childhood, meadows were typically cut only after flowering, often even in late July or August. They remembered that "the hay smelled incredible because there were so many flowers" (111) and that "there used to be a lot more blossoms" (112). As one farmer from Dravsko-ptujsko polje explained, "every household had a cow" (113), making meadows and their hay a central component of mixed farming systems. Farmers also recalled using coarse, late-mown hay as bedding material. Today, however, the agricultural roles once fulfilled by extensive meadows no longer hold the same relevance. As one respondent noted, "there is no need for it [extensive meadows] anymore" (113). A key reason for this shift is the decline of livestock keeping, particularly on the Dravsko-ptujsko polje, where many farms move towards arable production and the number of livestock heads has declined by a third since 2000 (SURS 2026). As nearly half (44%) of interviewed farmers from Dravsko-Ptujsko Polje had no livestock, several farmers explained, "this isn't profitable anymore, because we don't have livestock, so we plough for crops" (114), and "what would I do with a meadow if I don't need hay?" (115), which aligns with Włodarczyk-Marciniak et al. (2020) and Alavoine-Mornas and Girard's (2017) findings among Polish and French farmers, respectively. Among livestock farmers, the main obstacle to maintaining or establishing extensive meadows was the need for large quantities of high-quality fodder. To secure sufficient volumes of nutritious feed, respondents emphasised the need to mow early and frequently. Statements such as "we simply need as much feed as possible, so by the end of April, everyone is already mowing and making silage" (116) and "livestock production forces us [to mow early], as we must have feed for animals" (117) were common. Late-season biomass was repeatedly described as "just straw" (118) or "practically only flowers" (119). Farmers explained that delayed mowing leads to vegetation that "becomes old, woody, and worthless" (120) and "if you have animals, they won't eat old hay; you need young grass" (121). Additionally, the species composition of extensively managed grasslands, such as habitat types 6410 or 6510, is typically of lower nutritional value than of grass-dominated intensively managed grasslands (Tome 2000; Čop et al. 2004). As a farmer from Ljubljansko barje summed up, "this [maintaining extensive meadows] is for the municipal service, not for farming" (119). Overall, these findings illustrate that farmers largely view extensive management as fundamentally incompatible with the demands of contemporary livestock production. This perception was also reflected in the survey results, where preserving extensive meadows received a relatively low average score from an agricultural production perspective (mean = 2.2, SD =

1.44, on a 5-point Likert scale). Such a focus on producing high-quality fodder for intensive livestock production has also been observed among some groups of farmers in France (Alavoine-Mornas and Girard 2017) and in Sweden (Waldén and Lindborg 2018), where meadows are frequently abandoned due to low productive value. However, in our study area, it seems that the land is productive enough that more intensive use or transformation to arable land, rather than abandonment, as it is more profitable.

A smaller group of farmers viewed agri-environmental payments as a welcome form of support for maintaining at least some extensive meadows, as subsidies can help cover the labour and time required for late mowing. However, extensive management was most often considered to be appropriate for marginal or less productive areas, such as steep slopes, flood-prone or waterlogged land that are typical for habitats 7230 and 6410 without draining, shaded sites, or parcels that are difficult to access with machinery. As farmers explained, late mowing "only makes sense where intensification is not possible" (120) and was therefore associated primarily with small-scale or low-intensity farming systems rather than mainstream production. For most farmers, however, the payments were considered far too low to offset the economic losses associated with extensive management. Many stressed that late-season biomass has little or no market value. Several compared the payment to the revenue from arable crops, stating that "this isn't profitable" (122) and that "on a field you can actually earn something, but the meadow is meaningless" (123). Even those who recognised the ecological rationale of the measure emphasised that, in practice, "extensive management is for nature, not for the farm" (110), and that prevailing economic conditions compel them to prioritise more intensive systems. This has also been confirmed by econometric analyses that show that farms with late-mown grasslands in our study area would not be economically viable (Tome 2000).

## Conclusion

We conducted a semi-structured survey with 506 farmers in two Slovenian lowland regions to explore farmers' perceptions of extensively managed semi-natural meadows to inform possible conservation measures. We found that farmers value such meadows for their aesthetic and nature conservation value, recognising the diversity of wildflowers growing there and their importance as a habitat for other wildlife, such as pollinators. At the same time, due to shifts in production technology and farming orientation, such meadows have largely lost their importance for production. Our quantitative model shows that the production value of meadows is a much more important predictor of extensive meadow presence than the aesthetic value, replicating previous studies on farmers' landscape perceptions (Włodarczyk-Marciniak et al. 2020). Hence, extensive meadows are mostly conserved where intensification is not possible due to geo-physical constraints, such as frequent flooding and difficult access, and where farmers still use the hay for bedding. At the same time, social norms based on modern farming practices put an additional pressure on farmers to mow grasslands early and regularly to maintain a tidy appearance, which further discourages extensive management of meadows. This is in line with previous studies that show how important it is for farmers to present themselves as "good farmers" by keeping their land clean and tidy (Burton and Paragahawewa 2011).

It is interesting to note farmers' views on meadow conservation AECM, seeing them more as an additional income support for farming on marginal lands than an incentive for nature conservation. The current payments may be too low to compensate the opportunity costs for extensive meadow conservation in the otherwise intensively managed lowland regions. At the same time, however, additional resistance to entering AECM may also stem from conflicting values, as farmers may prioritise food production and high yield over simple income maximisation that AECM can provide (Saunders 2016). The fact that extensive meadows lead to lower production and require less work may make those who conserve such meadows and are paid by AECM appear "bad farmers" even to agricultural advisors, as they receive payments for these land, but don't use it to "produce food" (Novak et al. 2025).

Our results show that the conservation and restoration of extensive grasslands in lowland areas susceptible to intensification will likely be a large challenge due to their limited productive value. At the same time, a limitation of our study is that we define extensive meadows from an agricultural management point of view and do not explore how farmers' views and management decisions depend on different habitat types with different productive values. Consequently, we cannot predict the conservation of which habitats will be least favoured by farmers. AECM may motivate some farmers that recognise the conservation and aesthetic value of extensive meadows to maintain their extensive management system, particularly where intensification would be difficult and costly because of natural constraints. For most farmers, however, even higher payments may not outweigh the conflicting social norms and loss of yield that comes with conservation of extensive meadows, and their restoration seems even less likely. If the conservation and restoration of extensive meadows is a societal priority, an approach with more enforcement, depending less on farmers' voluntary action, may be needed at least in the protected areas where agricultural intensification is the predominant trend of land use change. However, care must be taken for such an approach to be well planned, well communicated and just to ensure that it is accepted by the farming community.

## Acknowledgements

The authors would like to thank the local agricultural advisory service for their assistance in organising data collection and the team of trained interviewers for their help in conducting the survey in the field.

## Additional information

### Conflict of interest

The authors have declared that no competing interests exist.

### Ethical statement

No ethical statement was reported.

### Use of AI

No use of AI was reported.

## Funding

This study was funded by the Slovenian Research Agency (research programme P4-0022 (B)) and by the Ministry of Agriculture, Forestry and Food and European Agricultural Fund for Rural Development (European Innovation Partnership project EIP VIVEK).

## Author contributions

Conceptualization: TŠ. Data curation: ŽA. Formal analysis: AN, ŽA. Funding acquisition: TŠ. Investigation: AN, ŽA. Methodology: ŽA. Project administration: TŠ. Supervision: TŠ. Visualization: ŽA. Writing – original draft: AN, ŽA. Writing – review and editing: TŠ.

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## Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information. Raw data that was collected in the study and used for quantitative analysis has also been deposited to a repository: https://doi.org/10.17898/10100. However, the dataset is still in review.

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## Supplementary material 1

### Translated questionnaire

Authors: Živa Alif, Ana Novak, Tanja Šumrada

Data type: docx

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Link: https://doi.org/10.3897/natureconservation.63.186090.suppl1

## Supplementary material 2

### List of model predictors

Authors: Živa Alif, Ana Novak, Tanja Šumrada

Data type: docx

Explanation note: A table with all predictors used in the BRT model, along with an explanation of each variable and its data source.

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Link: https://doi.org/10.3897/natureconservation.63.186090.suppl2

## Supplementary material 3

### Sample description

Authors: Živa Alif, Ana Novak, Tanja Šumrada

Data type: docx

Explanation note: A description of the sample of surveyed farms as well as of the generated presence/absence dataset of extensive meadows.

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Link: https://doi.org/10.3897/natureconservation.63.186090.suppl3